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Engineering Note

Date: August 16, 2002
Rev Date:

Project: Wiener Model PL6021 Power Supply
Doc. No: H020816A_Wiener_supply_testing

Subject: Testing for Use in MINOS

This note presents the findings of tests performed on the Wiener model PL6021 power supply received for evaluation. This unit is being considered as the low voltage power source for the MINOS electronics crates. This note describes the tests and compares the differences between the Wiener supply and the 'Specifications for the MINOS Front End Power Supplies'.

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Summary & General Overview

1.1 Testing Summary

1.1.1 Vendor's written specifications.

1.1.1.1 The power supply, as tested, meets all of the Vendor's specifications.

1.1.2 MINOS written specifications

- With regard to the MINOS written requirements, the power supply differs in the following respects: Reference document **'Specification for the MINOS Front End Power Supplies'** by Gary Drake, Argonne National Laboratory, Catherine James and Robert Plunkett, Fermilab: Version 3.1 November 12, 2001
- Technology - Section 2.2.1 MINOS specifies that only linear supplies with series pass transistor regulators were to be considered. The Wiener power supplies use switching technology that is specifically prohibited. However, the Wiener supplies combines power factor correction with high frequency switching to provide a low noise power supply comparable, and in many ways better, than linear technology (for example weight). The requirement for not using switchers may be unreasonable.
- Noise - Section 2.3.1 specifies noise and ripple to be less than 1.5millivolts RMS. The Wiener supplies have 2millivolts RMS. This specification should be reconsidered along with item #1 above.
- Load Protection, Fault Recovery & Safety - Section 2.5.1 the current sensing specification states that the supply should self-recover from a fault condition. The Wiener supplies do not meet this criterion. A fault turns the supply off and it must be commanded back on.
- Overload Protection and Recovery - Section 2.5.3 requirement is also not met by the Wiener supply. This specification might also be reconsidered since this type of action can go unnoticed and cause circuit damage.
- Circuit Breakers and Switches on Input Power Lines - Section 2.5.5.2 specifies a minimum line circuit switch per supply. The Wiener supplies have no switch or protection device on the input line as part of their assembly. These devices would need to be added externally.
- Visual Indicator - Section 2.5.7 This feature is not provided by the Wiener supply. If fuses are required an external set of indicators will be needed.
- Input and Output Connectors - Section 2.9.1 Line Cord is not part of the supply.
- Specifications for Each Voltage - General Considerations Section 3.1.3 Rated Current Defined is not met by the VANA4 output. The specification asks for 50Amps and the Wiener is only rated for 46Amps.

1.2 General Impressions/Comments

- Two supplies were received for testing at DZero the first part of Aug. 2002. The units were uncrated and a few of the screws were loose with one lying in the packing material. No damage, however, was found on any part of the units.
- The general impression of the supply is good to excellent. The supply is modular in that the supply 'guts' can be swapped out from the front of the unit. The supply is totally socketed and requires no tools to change. The front panel is removed and the inner supply chassis is unscrewed and pulled out. All connections on the back to the wiring harness can be left untouched.
- The supply is microprocessor controlled so it can be configured or controlled in a variety of ways. There is a CANbus interface, an RS232 PC interface and the front panel or local interface. The PC and local control was the only method used during testing at this time.
- The output terminals on the back of the supply are not very convenient to work with. They are close to one another and require special tools to make the connections properly. With properly sized cable crowding may be an issue.
- The sensing connections could be a source of trouble. Each wire must be connected separately to its respective location and errors could occur. Also improper termination could occur due to clamping on the insulation instead of the wiring.
- Only one supply was tested at Fermilab. The second supply will be taken to Argonne Lab and connected to the electronics for evaluation before a final decision is made.

2 Output Voltages and Currents

2.1 Output Voltage & Current

2.1.1 The Wiener supply has more than enough current for the expected load requirements. The table below shows the percentage of current used from the total current available and the percentage of requested power from the available power. The only exception is the 12Volt VANA4 output. The requested value of 50Amps is not met.

2.1.2 The following table compares the written specification for MINOS low voltage crate power to the Wiener supply being evaluated. Table 1 from section **3.2 Ratings Defined** is the top portion of this comparison with the Wiener supply characteristics in the bottom portion. In general the supply is being operated below 65% of its rating per specification 3.1.3

Table 1 Written specifications verses Wiener specifications.

Written Spec.	VCC	VDIG	VANA1	VANA2	VANA3	VANA4
Voltage	+5 Volts	+3.3 Volts	-12 Volts	-5 Volts	+5 Volts	+12 Volts
Delivered Current	28 Amps	52 Amps	< 1 Amp	13 Amps	26 Amps	32 Amps
Delivered Power	140 Watts	170 Watts	<5 Watts	65 Watts	130 Watts	384 Watts
Rated Current	45 Amps	80 Amps	1 Amp	20 Amps	45 Amps	50 Amps
Rated Power	225 Watts	265 Watts	12 Watts	100 Watts	225 Watts	600 Watts

Wiener PS	U0	U3	U5	U7	U4	U1
Available Current	115 Amps	115 Amps	11.5 Amp	30 Amps	115 Amps	*46 Amps
% Available-Rated	39%	70%	9%	67%	39%	109%
Available Power	550 Watts	550 Watts	138 Watts	150 Watts	550 Watts	550 Watts
% Available-Rated	41%	48%	9%	67%	41%	109%

*Does not meet the 50Amp request but should supply the required current limit value.

2.1.3 The output voltage at turn-on is ramped from zero to the output voltage setting. The rate (dV/dt) is not significantly changed with load current.

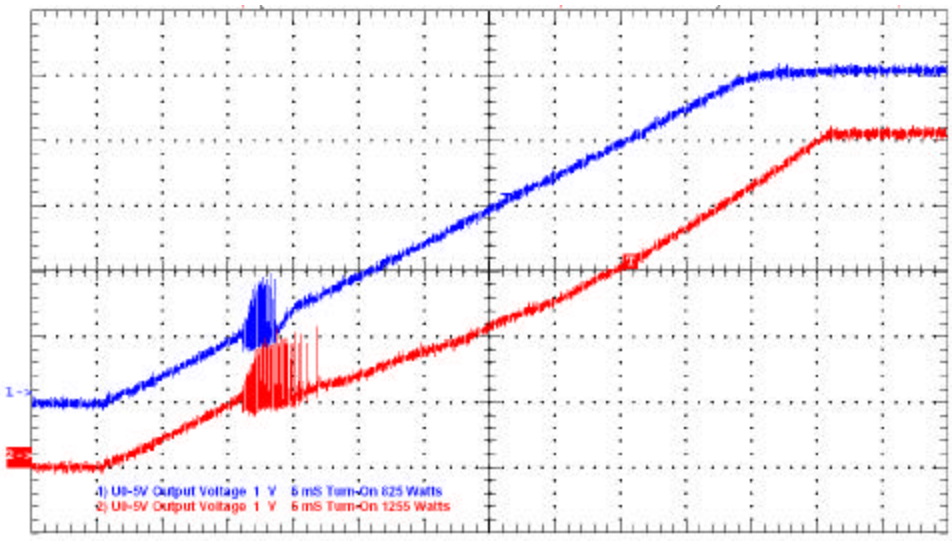

Figure 1 Voltage during turn-on at different power levels

3 Output adjustments

3.1 Output Adjustments

3.1.1 The output voltage for each of the six (6) outputs is adjustable over the range listed in the table below. Additionally the output current limit, under voltage and over voltage and current protection levels can be set. These values are easily set with the PC RS232 interface program or CANbus connection. They can be set from the front panel but not without knowledge and practice of the procedure. Manual setting of the output voltage can be done with the switches on the top of the chassis. See the supply manual for additional information.

Output Voltage Adjustment range

Table 2 Output Voltage Adjustment and Limits.

	U0	U3	U5	U7	U4	U1
Nominal Voltage	+5 Volts	+3.3 Volts	-12 Volts	-5 Volts	+5 Volts	+12 Volts
Adjustable Range	2V to 7V	2V to 7V	7V to 16V	2V to 7V	2V to 7V	7V to 16V
Maximum Output	115A or 550W	115A or 550W	11.5A or 150W	115A or 550W	30A or 150W	46A or 550W

4 Over-current limits

4.1 Over-Current Adjustments

4.1.1 The current limit can be set for each output. The supply will provide current up to the set level. As the current attempts to go above the set level the output voltage will begin to drop. If the trip point is above the limit point the output voltage will continue to lower as more current is demanded until the under-voltage trip point is reached.

4.1.2 The current monitoring for tripping the supply is a separate setting. When this setting is below the current limit point, which is the normal mode of operation, it will trip off from an over current condition. The supply should not trip on an under voltage unless something is broken. If the trip level is above the limit level the supply will trip on an under voltage if too much current is demanded as described above.

4.1.3 The current limit and current monitoring levels can be set to the same value.

5 Over-voltage protection

5.1 Over-Voltage Adjustments

5.1.1 The output over-voltage limit can be set for each output. If the output voltage exceeds this setting the supply trips off and the output is shorted to ground.

5.1.2 This might occur as a result of large current changes associated with inductive loading. This feature can catch very fast transients, at least less than 100us in length.

6 Input current/Efficiency

6.1 Efficiency

6.1.1 Line current was measured at various power levels to determine the efficiency of the supply. In general switching supplies are designed for maximum efficiency at maximum loading. For this reason it is usually better to run them at 80% of their rated power rather than over rating them and operating at less than 50% of capacity. Looking at the curve of the measured efficiency it can be seen that this supply will be operating in the flat maximum efficiency region of the curve.

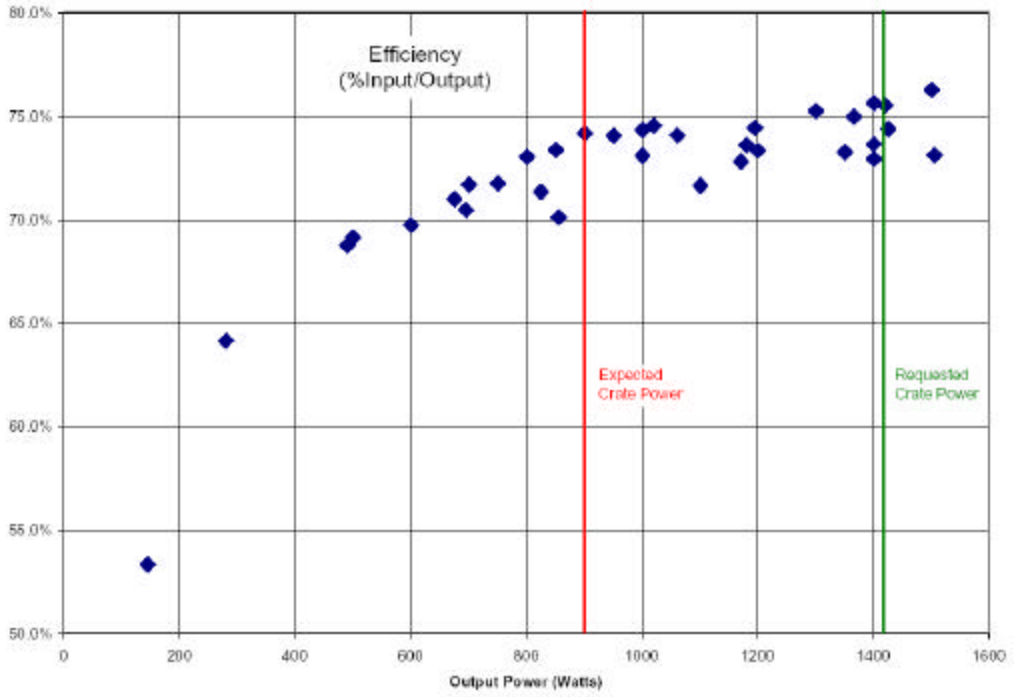

Figure 2 This is a graph of the output to input efficiency.

6.2 Line Current Harmonics

6.2.1 Line current harmonics vary with loading because there are some higher frequency structures present on the line current. Here is a scope picture at various power levels. Here is an FFT at full power and nominal power levels. Included is a base line. The first peak is at 60Hz, the second peak is the third harmonic at 180Hz etc.

6.2.2 Although not mentioned in the specifications there must be power factor correction circuitry since the line current represents a reasonable sine wave as if it is supplying a resistive load.

7 Output voltage transients

7.1 Output Dynamics

7.1.1 The output loading was programmed to change between two current settings while monitoring the output voltage. The scope probe was place directly across the output for this measurement.

7.1.2 Here are a few of the outputs with transient loading. Only the three outputs connected to the fancy load unit were tested at this time.

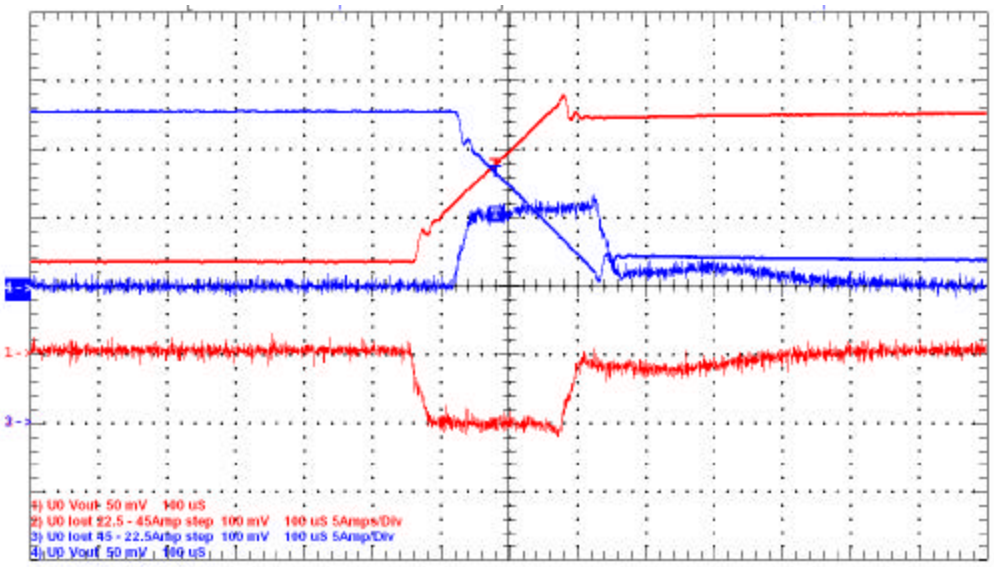

Figure 3 U0 with a step load from 22.5Amps to 45Amps at 0.1Amps/us.

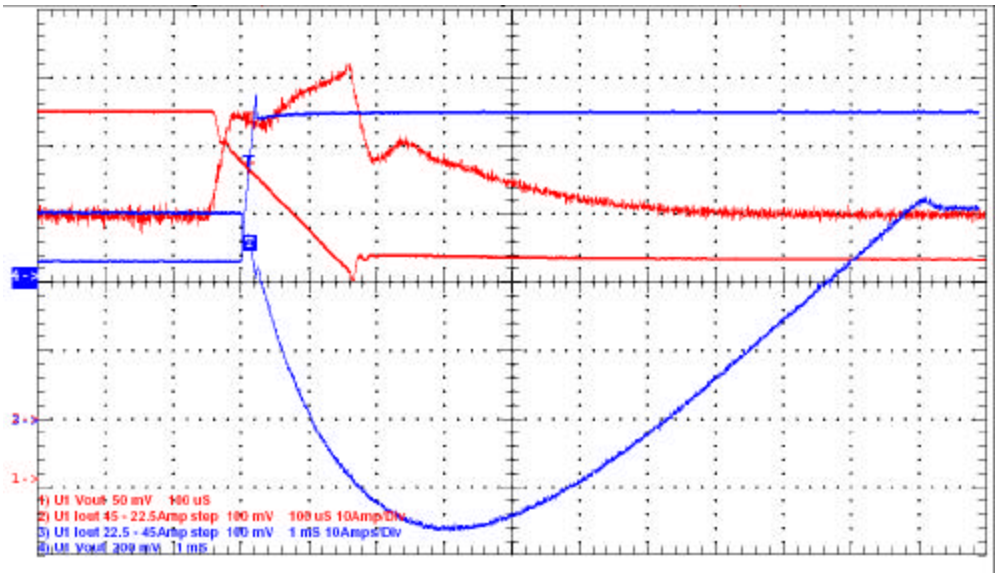

Figure 4 U1 with a step load from 22.5Amps to 45Amps at 0.1Amps/us.

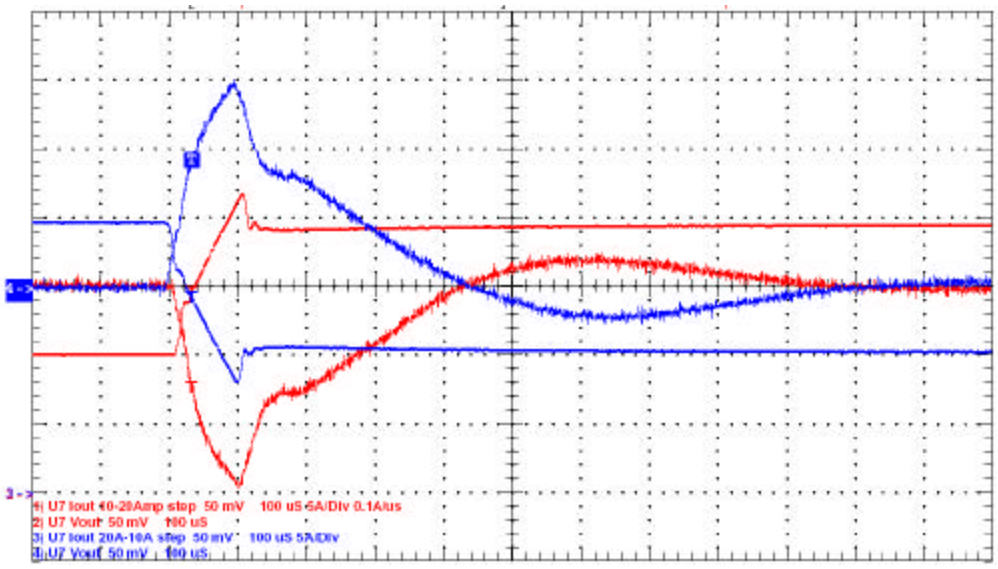

Figure 5 U7 with a step load from 10Amps to 20Amps at 0.1Amps/us.

8 Temperature

8.1.1 The supply was operated at the Wiener RATED current until equilibrium was reached. The room temperature was approximately 24C and the air temperature exiting the unit was typically 45C and in the warmest location, 70C. Running at the expected current levels the supply was only warm to the touch.

9 Long term test at 'Delivered current'

9.1.1 The supply was configured for the following specifications. The voltages, current trips and limits are set to the values in the table below. The supply was operated at 70% of the Rated Current level for cooling tests and continuous operation. This is the expected loading during normal operation with MINOS electronics.

Table 3 Current Trip and Limit settings

Wiener PS	U0	U3	U5	U7	U4	U1
Current Trip	45 Amps	80 Amps	1 Amp	20 Amps	45 Amps	46 Amps
Current Limit	45 Amps	80 Amps	1 Amp	20 Amps	45 Amps	46 Amps
70% Current	32 Amps	56 Amps	1 Amp	14 Amps	32 Amps	35 Amps

70% of the Rated current is the typical load expected.

10 Ripple and HF noise

10.1 Noise Measurements

10.1.1 The output noise of this supply is very low for a switching type supply. Looking at U0-5V output, the peak-to-peak noise levels measurements are summarized in the table below. This is representative of all outputs.

Table 4 Peak-Peak noise voltage at 10 & 100 Amps.

Scope Bandwidth	150MHz	20MHz
Output Current @ 10Amp	150mVpp	12mVpp
Output Current @ 100Amp	330mVpp	20mVpp

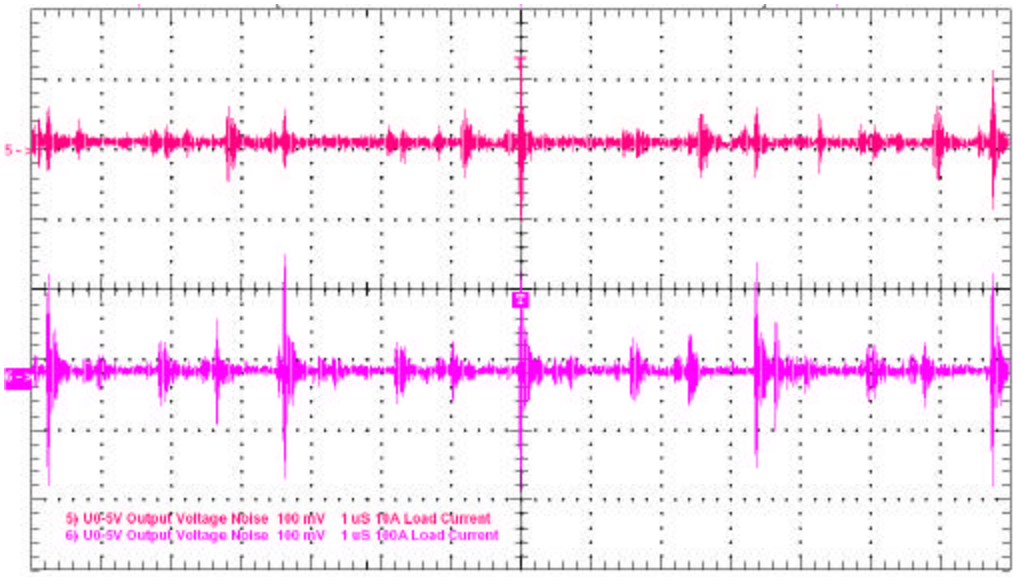

Figure 6 Scope capture at two current levels.

Using the measurement function on the scope a noise level value of approximately 2mVRMS at 100Amps was measured.

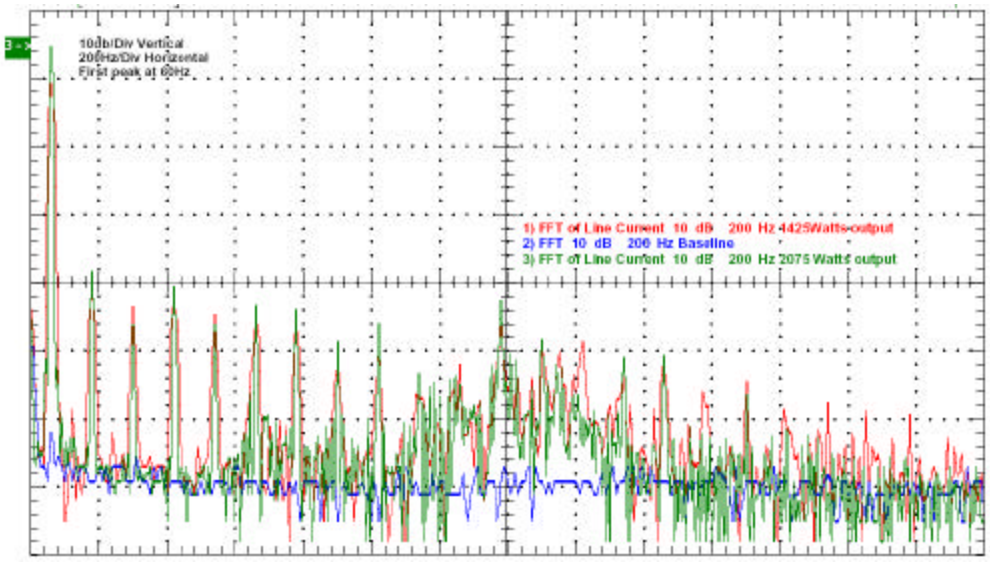

Figure 7 Line current harmonics using scope FFT math function.